Forest Pest Management

South Sierra Shared Service Area
Sonora, California

Report No. C99-1

3420
January 22, 1999

Forest Pest Influences in Converse Basin, Hume Lake Ranger District, Sequoia National Forest

John Pronos
Plant Pathologist

INTRODUCTION/BACKGROUND

Management of the 4700 acres within Converse Basin, classified as mixed conifer, is controlled by the giant sequoia groves present. In general, the area has excellent site quality (Dunning 1 and 0) and lies between 5800 and 7000 feet elevation just south of the Kings River. Two events which had a dramatic effect on the vegetation in the Basin were heavy logging in the late 1800's, which removed much of the oldest giant sequoia, and the McGee wildfire of 1955. The area was logged again in the early 1980's. Fire exclusion has lead to invasion and overstocking by white fir and incense cedar. Current direction is to protect, restore and preserve the giant sequoia resource.

Inventory data shows that many sites have basal areas of more than 250 sq. ft./acre and most sites have 4 or more standing snags plus 10 or more down logs per acre. Mortality is comprised of white fir, sugar pine, ponderosa pine, and incense cedar, with small amounts of giant sequoia and California black oak. Most of the dead trees are white fir.

On July 22, 1998, Lew Jump, from the Sequoia National Forest Supervisor's Office and I visited Converse Basin. The purpose of our visit was to determine the causes of mortality and assess the current activity of insects and pathogens. This information can be used by the Forest in forming its future management direction.

OBSERVATIONS

There was very little current mortality (that which occurred in the past year or two) present. The dead trees still standing represent mortality that occurred over the past 10 years. The below normal precipitation between 1988 and 1993 was likely a predisposing factor for this mortality. Insects and pathogens will be discussed by the tree species they affect.

White Fir

White fir at one site inspected was found infected by annosus root disease (*Heterobasidion annosum*). This fungus was confirmed by finding viable conks or fruiting bodies in several fir stumps. Older fir mortality was present and some mature trees showed evidence of crown decline, although top-kill was not observed. Numerous stumps from past logging activities were scattered through the site, and these are the most likely avenue through which annosus root disease became established at this location. (See the descriptions of pest biologies at the end of this report.) *H. annosum* in true fir acts as a root and butt rot and does not cause rapid tree mortality in large fir. It may lead to windthrow or reduce vigor enough to allow insects to kill the tree.

The tree species susceptible to this type of *H. annosum* include red and white fir, Douglas-fir and giant sequoia. Incense cedar and sugar pine, which are also present at the site, are not hosts.

At a second site, a currently dying white fir was extensively colonized by *Armillaria mellea*, another root pathogen. Thick, white mycelial fans of this fungus were found at the base of this tree when the bark was removed. Galleries of the fir engraver beetle (*Scolytus ventralis*), were evident on the outer sapwood. Evidence of *S. ventralis* activity was common on standing dead and down material in Converse Basin. In the Sierra Nevada it is common for root disease infected trees to be colonized and killed by the fir engaver beetle. Armillaria root disease is not found as commonly as annosus root disease in mixed conifer stands, although all conifer species are susceptible to this pathogen.

Sugar Pine

Groups of sugar pine snags are common in Converse Basin. We examined one group of at least 15 closely spaced sugar pine snags that varied from 10 - 40 inches DBH. Our estimate was that these trees died between 3 and 8 years ago, which coincides with a general drought period in the Sierra Nevada. Galleries of the mountain pine beetle (*Dendroctonus ponderosae*) were found under the bark of the most recently killed trees. The older sugar pine snags were deteriorated too much to reach any conclusions as to cause of death. Mountain pine beetle is the most common insect in the Sierra associated with sugar pine mortality.

Lethal bole cankers of white pine blister rust (caused by *Cronartium ribicola*) were found on several sugar pine seedings, but were not seen affecting larger trees. *Ribes* sp., the alternate host of this non-native fungus, was common and abundant in small openings such as landings created during past logging entries. It appears that blister rust has not been active in the area for very long, but does have the ability to become more common depending on future management activities. Blister rust can be very lethal to sugar pine seedlings, saplings and poles if they are not genetically resistant to the pathogen.

DISCUSSION AND MANAGEMENT ALTERNATIVES

The insects and pathogens that are present in Converse Basin, and the conditions under which they have been active, are common in the Sierra Nevada. We did not see any situations that were unusual or outside of normal patterns, but still, these agents have the potential to cause significant damage to stands. Alternatives for dealing with these pests or the stand conditions that foster them are described below.

1. Do Nothing/No Management

The insects and pathogens established in Converse Basin will continue to affect vegetation. Currently infected fir within annosus root disease centers will keep deteriorating while the fungus spreads through root contacts to healthy trees. The absence of management activities has little or no effect on existing annosus root disease centers but will tend to minimize the initiation of new infections. Armillaria root disease is not as persistent as annosus and can be expected to cause occasional but not significant mortality. Mortality of sugar pine regeneration from white pine blister rust should remain fairly constant. Activities that increase the amount of Ribes in the Basin, however, will lead to increased future sugar pine mortality from this rust.

Bark beetles, including the mountain pine beetle, fir engraver and the western pine beetle in ponderosa pine will periodically cause mortality, mainly in trees under stress from overstocking, recurrent drought and disease infection. Moisture conditions over the past few years have been favorable and bark beetle-related mortality is low. Biological systems do not remain static, however, and over time biomass and stocking will increase, as will competition between trees.

In general, the interactions between insects, pathogens and stand conditions will continue to cause tree decline and mortality. The results can include: 1) reduced tree growth/vigor; 2) increased numbers of snags and down material; 3) reduced stocking; 4) reduced structural diversity; 5) unregulated openings; and 6) increased fuel loadings. Whether these conditions are considered positive or negative will depend on the management objectives for Converse Basin.

2. Regulate Stocking

The objective here is to thin overstocked aggregations to levels consistent with site quality that will create and maintain vigorous trees and stands less susceptible to successful attack by bark and engraver beetles. Desirable stocking levles in mixed conifer stands are not well established, but reducing stocking to between 40 and 70% of normal has been shown effective in reducing bark beetle related mortality in California pine stands. ("Forest Pest Conditions in California - 1997", Annual Report of the California Forest Pest Council, Sacramento, CA, 32pp.) Stand Density Index, also developed for eastside pine stands, may provide some general guidance for stocking in Converse Basin. (Oliver, W.W. 1995. Is self-thinning of ponderosa pine ruled by Dendroctonus bark beetles? In: Eskew, L.G. Forest health through silviculture. Proc. 1995 Natl. Silviculture Workshop; 1995, May 8-11; Mescalero, NM. USDA For. Serv. Gen. Tech. Rep. RM-GTR-267. 246p.) In addition, thinning provides an opportunity to remove poorly growing, diseased, defective, or unwanted species of trees.

3. Regulate Species Composition (Improve Species Diversity)

The bark and engraver beetles that have been active over the past 10 years in Converse Basin are the species that kill true fir and sugar pine. Annosus and Armillara root diseases were found infecting white fir, and white pine blister rust is restricted to sugar pine. It could be advantageous to favor ponderosa and Jeffrey pines, which account for only small amounts of existing mortality. Maintaining species diversity and balance can help prevent future insect mortaliy as long as stocking is also kept at reasonable levels. Natural regeneration of sugar pine will likely be killed by blister rust. If any planting is done in the Basin, rust resistant sugar pine should be used.

4. Root Disease Management

A. **Sanitize Areas Affected With Annosus Root Disease**. Most of the white fir within root disease centers is either already infected or will be in the future. Keep in mind that giant sequoia is a host for *H. annosum*. Failure of mature sequoia with annosus root disease has been documented in the Sierra Nevada, but mortality has not. A challenge with the fir "type" of this root pathogen is that infected trees do not always show obvious above-ground symptoms. This means that identifying root diseased trees and the boundaries of root disease centers may be difficult. If true fir growth rates or mortality are unacceptable, consider removing all host trees within disease centers and convert to non-host species such as ponderosa, Jeffrey or rust resistant sugar pine. *H. annosum* will remain active on the site and may continue to expand underground to nearby fir and giant sequoia.

A more aggressive approach would be to sanitize the root disease centers and remove an additional strip of green trees from the adjacent healthy stand. The intent here is to cut uninfected trees far enough in advance of annosus root disease to allow non-pathogenic root inhabiting fungi to invade and colonize root systems instead of *H. annosum*. Essentially, this would deny annosus access to these roots, and the enlargement of centers would be stopped.

Based on the size and spacing of trees in Converse Basin, the buffer strip would have to be 80-100 feet wide. Treating all cut stumps with Sporax would be necessary for the treatment to be effective.

B. **Sporax**. Sporax is a pesticide effective in keeping *H. annosum* from infecting freshly cut stumps, and, therefore prevents the start of new disease centers. Sporax does not control the fungus if it is already established in roots. Use of this preventative pesticide is routine in many pine type situations, especially on the east side of the Sierra. Use of Sporax on true fir is less common because of the difficulty in identifying diseased areas and because annosus is already established in so many mixed conifer and true fir stands. Still, Sporax will prevent the start of new disease centers and its use should be considered wherever white fir will remain as a stand component. Because giant sequoia is a host for annosus root disease, sporax use may be desirable, if not essential, where white fir is removed in the vicinity of sequoia.

BIOLOGIES OF PEST ORGANISMS IN CONVERSE BASIN

Annosus Root Disease In True Fir

Heterobasidion annosum (formerly *Fomes annosus*) is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone and a few brush species (*Arctostaphylos* spp. and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all the National Forests in California, with incidence particularly high on true fir in northern California campgrounds. Incidence is somewhat higher in older, larger fir stands and in stands with high basal areas (over about 330 square feet/acre).

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers begin by aerial spread of spores produced by the conks and subsequent colonization of freshly cut stump surfaces or wounds on living trees. The fungus then spreads through root contacts into the root systems of adjacent live true fir. Local spread of the fungus from a stump typically results in the formation of a disease center, with dead trees in the center and fading trees on the margin. These centers usually continue to enlarge until they reach natural barriers such as stand openings or non-susceptible plants.

In pines, *H. annosum* grows through root cambial tissue to the root crown where it girdles and kills the trees. In less resinous species such as true firs, the fungus sometimes kills trees, but more frequently it is confined to the heartwood and inner sapwood of the larger roots where it causes a chronic butt and root decay and growth loss. Thus, while infection in true fir usually does not kill the host, it does affect its growth and thriftiness. Losses in true fir from *H. annosum* are mainly the result of windthrow because of root decay, and reduced root systems that predispose trees to attack and eventual death by the fir engraver beetle. Field observations suggest that vigorous young firs are usually able to regenerate root tissues faster than they are lost to the root disease. But when true firs slow in growth because of stand and/or site conditions, root development decreases to where there is a net loss in roots and the trees slowly decline due to the gradual loss of their root systems. This decline may take 10 to 20 years before tree death occurs.

There are two pathogenic strains of the fungus that differ in their ability to infect various conifers in California. The "P" or pine type infects and kills all pines (although susceptibility of pine species vary), in addition to incense-cedar and western juniper. The "S" or fir type infects true fir, Douglas fir and giant sequoia. Knowing which type is active in a stand is important, and will allow favoring alternate conifer species because the fungus strains do not cross infect between the two groups listed above.

Armillaria Root Disease

Fungi in the genus *Armillaria* are widely distributed in soils and usually live as saprophytes on dead wood or other organic matter. Until about 1980, it was thought that only the species *Armillaria mellea* existed in North America. Recent research, however, has shown that nine species may be present. In California, *A. mellea* is the most common species, followed by *A. gallica*. The following discussion refers to *A. mellea.*

This fungus has a wide host range, including virtually all woody plants in California. It is frequently associated with hardwood roots, especially oaks. Healthy oaks are resistant to the fungus. This resistance disappears, however, when trees are weakened, stressed, cut, or killed, and Armillaria may then rapidly colonize and decompose roots and sometimes entire root systems. Stresses that have been linked to increased damage from this root disease include insect defoliation, drought, excessive soil moisture, poor planting techniques, bark beetle attack, air pollution injury, and nutrient deficiencies.

The organic material used as a source of nutrition is called a food base. With a large food base to utilize, the fungus becomes more aggressive and moves to the roots of nearby trees by means of root contacts and rhizomorphs. Rhizomorphs are structures that resemble black shoestrings and grow like roots through upper soil layers. The predominant method of tree to tree spread in California is via root contact; rhizomorphs are more important and prevalent in other areas of the country.

Armillaria is capable of directly penetrating through the intact root bark of living trees, and once it reaches the cambium it usually grows rapidly, producing a flat, white, leathery, fan-shaped mycelial mat. Rhizomorphs are often associated with the mat. If the fungus reaches the root collar it girdles the stem and kills the tree. After Armillaria successfully colonizes a root segment or root system, it continues to decay the wood and causes a white to yellowish, wet, stringy rot. This rot does not usually extend up the stem more than a few feet above the soil line.

Clusters of mushrooms may be found in the fall at the base of infected dead or dying trees and stumps. These mushrooms may also grow directly out of the soil near the food base. Spores produced by fruiting bodies are not an important source of new infections or long distance spread.

Fir Engraver

The fir engraver (Scolytus ventralis) attacks both white and red fir in California. Trees ranging in size from large saplings to overmature sawtimber are susceptible. Attacks can cause patch-killing of cambium along the bole, top-kill, or tree death. Top-kill or death occur most often in firs that have been weakened by root disease, dwarf mistletoe, overstocking, soil compaction, sunscald, logging injury, or drought. The fir engraver also breeds in slash and windthrown trees.

The fir engraver usually completes its life cycle in one year, sometimes two. Adults fly and bore into trees or green fir slash from June to September; larvae, pupae, and adults over-winter under the bark. Pitch tubes are not formed as they are with pine bark beetles; the usual evidence of attack is boring dust in bark crevices along the trunk and pitch streamers on the mid and upper bole. Trees colonized early in the summer may begin to fade by early fall, but those colonized later in the year usually do not fade until the following spring or summer, often after the beetles have emerged.

Mountain Pine Beetle

The mountain pine beetle, Dendroctonus ponderosae, attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 4 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is the general rule, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine.

Attacks may extend from the root collar up to near the top. Pheromones released during a successful attack may attract enough beetles to result in a group kill. Pitch tubes and red boring dust in bark crevices or on the ground indicate successful attacks.

The adults bore long vertical egg galleries and lay eggs in niches along the sides of the gallery. A "J"-hook is common at the lower end of the gallery. The hatching larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

The sapwood of successfully attacked trees soon becomes heavily bluestained. The bluestain fungi probably aid in overcoming the defenses of the host tree.

Natural factors affecting the abundance of the mountain pine beetle include low winter temperatures, nematodes, woodpeckers and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases snd mortality increases. Relieving stress by thinning dense stands can prevent some group kills. Individual high value trees undergoing temporary reversible stress may be protected from attack by application of insecticide to the bole.

White Pine Blister Rust

Blister rust (*Cronartium ribicola*) is caused by an obligate parasite that attacks sugar and western white pines and several species of *Ribes*. The fungus needs the two alternate hosts to survive, spending part of its life on 5-needled pines and the other on *Ribes*. The disease occurs throughout the range of sugar pine to the southern Sierra Nevada, but has not been reported further south. Infection of pines results in cankers on branches and main stems, branch mortality, top kill, and tree mortality.

Spores (aeciospores) produced by the fungus in the spring on pine bole or branch cankers are wind-disseminated to *Ribes* where they infect the leaves. Spores (urediospores) produced in orange pustules on the underside of the leaves re-infect other *Ribes* throughout the summer, resulting in an intensification of the rust. A telial spore stage forms on *Ribes* leaves in the fall. Teliospores germinate in place to produce spores (sporida) which are wind-disseminated to pines and infect current year needles. Following infection, the fungus grows from the needle into the branch and forms a canker. After 2 or 3 years, spores are produced on the cankers and are spread to *Ribes* to continue the cycle. Although blister rust may spread hundreds of miles from pines to *Ribes*, its spread from *Ribes* back to pines is usually limited to a few hundred feet.

Branch cankers continue to enlarge as the fungus invades additional tissues and moves toward the bole. Branch cankers within 24 inches of the bole will eventually form bole cankers (these are called **lethal** cankers). Bole cankers result in girdling and death of the tree above the canker. Cankers whose closest margins are more than 24 inches from the main bole are unlikely to reach the bole and only branch flagging will result (these are called **non-lethal** cankers).

Environmental conditions are critical for successful infection and limit the disease in most years. Moisture and low temperatures favor infection of both hosts, and must coincide with spore dispersal for infection to occur. In California, these conditions occur only infrequently, usually in cool moist sites such as stream bottoms or around meadows. In so called "wave years" when favorable conditions occur, high levels of infection can result. Wave years in California have occurred at approximately ten-year intervals in the past. As one moves from sites most favorable for rust to less favorable sites, the frequency of wave years decreases.